Coll. Antropol. **32** (2008) 2: 433–441
Original scientific paper

Development of Biomotor Characteristics and Athletic Abilities of Sprint and Throw in Boys Aged Six to Eight Years

Tonči Bavčević, Nebojša Zagorac and Ratko Katić

Faculty of Natural Sciences, Mathematics and Kinesiology, University of Split, Split, Croatia

A B S T R A C T

The aim of this research was to examine the influences of specially programmed physical education lessons on biomotor development in boys, as well as the influence of those changes on relations between the set of morphological and motor variables and athletic variables for the assessment of sprint and throw abilities. For this purpose, an overall sample of 325 primary school first grade pupils from the city of Split area, aged 6–8 years, was divided into control group of subjects (N=140) attending regular physical education lessons and experimental group attending specially programmed lessons based on athletics, sports gymnastics and games elements as well as on general preparatory exercises. The relations between the predictor set of variables composed of 4 morphological measurements and 6 motor tests with the criteria of sprint and ball throwing were established by the regression correlation analysis at the beginning and at the end of the academic year. Both groups of subjects achieved positive quantitative resultant shift between the two points of measurements, whereas this shift was more significant in the experimental group in relation to the control group, especially in motor abilities coordination of flexibility, movement frequency and of explosive, repetitive and static strength. The number of significant predictors for criteria variables of sprint and ball throwing increased in the final measurement in relation to the first one in both groups of subjects. While in the control group the best results predictor in sprint were the motor abilities of explosive strength and trunk strength, the best results predictor in sprint in the experimental group were coordination, trunk strength, flexibility and explosive strength. As far as the morphological characteristics are concerned muscle mass has a positive and body mass a negative effect on the sprint result. The best results predictor in ball throwing are explosive strength and trunk strength which, in the experimental group of pupils are additionally followed by coordination development as well as the overall body mass development. By comparison of these and the earlier obtained results, a new work model for the disciplines of sprint and throws within the athletic sport school, has been proposed.

Key words: *biomotor development of boys, athletic abilities, kinesiologic education*

Introduction

Top results are being achieved earlier and earlier than before. Therefore the need arises to start with the systematic work in sports in general earlier than before, meaning at the age 6–8 years. Accordingly, training within a sport school is usually drafted in order for children to adopt in average in the course of the first two years as many basic motor movement structures as possible, and at the same time the training should firstly influence the development of the basic motor and functional abilities as well as some desirable morphological characteristics. This is exactly the period of primary education which represents, from the aspect of growth and development, one of the most important periods in child phylogenies. The anthropologic status is still not in this life phase completely defined structurally, therefore the possibilities of positive action on its development are huge[1–3]. As a result of the previously stated reasons it is important to create some optimal preconditions for the development and motor status structuring, above all by applying programmed and controlled kinesiologic treatment[4–5].

It has been proved that contact between children and organized sport activity in athletics should occur at age 7–10 years by Travin and Suslov (1989)[6], while guiding towards athletics disciplines groups should take place at the age of 12 by Šnajder (1990)[7].

Received for publication April 25, 2008

For the assessment of the morphologic and motor status in the school system of the Republic of Croatia a standard battery of 10 variables is used[8–12].

At the same time, the morphologic set of only four variables manifested as sufficient for obtaining basic information about morphological status development characteristics in boys, aged 7–11 years[10,13]. Simply, the development processes tend to establish optimal results between all somatotype elements-components. These relations will determine motor efficiency due to interactional relation of the morphological and motor system.

Likewise, the selected set of motor variables defines well the motor status of pupils, 7–11 years of age[10,13]. Namely, during the process of motor development mostly two mechanisms responsible for motor efficiency are formed. These mechanisms are the mechanism for energetic regulation and the mechanism for movement structuring manifestation. The former is mostly responsible for the energetic component and the letter for the information movement component. Since it is obvious that the performance of each movement and/or movement structure depends at the same time on energetic and on informational component, so it represents assumed and central mechanism, which integrates functions of both subjected mechanisms.

Many research results which have often been conducted on top quality athletes, participants of Olympic Games and European and world championships, imply that the basic body morphological function is of extreme importance for athletes[14–18].

In the above-mentioned researchs Heath-Carter somatotyping method was frequently used in order to decribe human body thoroughly. The application of the three components (endomorph, mesomorph and ectomorph) proved to be of extreme interest to the description of the sportsmen characteristics. Thus, the relations of somatotype component with regard to athletic discipline can also be established: in athletes of throwing discipilnes the mesomorphic component dominates along with the average endomorphic, runners are balanced mesomorphed, then ectomorphed with minimum endomorphic component, while sprinters are some more mesomorph than the middle and long distance runners.

The canonical analysis results by Katić (1996)[19] exhibited mostly negative connection of adipose tissue and the manifestation of athletic abilities in the form of sprint, throw and long distance running in boys, and especially in girls. Subcutaneous adipose tissue acts as ballast mass since it reduces relative strength which is necessary for effective sprint running[20]. The importance of the relative strength for jumps and running manifestation has been established by Ball et al. 1992[18]. Hence, in boys and especially in girls, expressed adipose tissue with insufficiently developed muscle tissue reduces the manifestation of motor abilities. For athletics the results also yielded that more expressed muscle tissue, without adipose tissue, favours the sprint realisation, while ectomorph along with the moderate representation of mesomorph and endomorph favours the throw realisation, and gracious body structure with low realisation of all somatotype components favours long distance running realisation[19].

It can be presumed that the development of morphological characteristics and motor abilities as situational-motor abilities for athletics goes side by side, and that there is an interactional, i.e. symmetrical connection between the two.

Thus the basic aim of this research emerges from the above and it refers to the establishment of relations between morphological and motor variables set and athletic variables for ability assessment of speed running and throwing, applied on children six to eight years of age. The results will be used for more efficient orientation and selection of children for athletics as basic sports activity.

Muscle tissue and subcutaneous adipose tissue are significantly less genetically determined than the skeleton and are therefore more affected by the changes of the conditioning process as well as the sport training. The latter can, to a certain extent, influence the forming of a desirable morphological structure.

Subjects and methods

The study sample included 325 first graders of the Split primary schools. At the beginning of the experimental procedure they were 7 years ± 2 months old.

The general specimen was divided into two subsamples. The *control group* of subjects (N=140) attended regular physical education lessons, while the *experimental group* (N=185) attended specially programmed lessons based on athletics, sports gymnastics and games elements as well as on general preparatory exercises, in the period of one academic year (Table 1). Therefore, all children went through the programmed kinesiologic transformation, procedures lasting 9 months; they were also measured by two control points (± 10 days). The purpose of transformation procedures was to support biological growth and development as well as to influence the motor abilities of the widest spectrum.

A standard battery of 10 variables currently used in the educational system of the Republic of Croatia was employed to assess the morphological, motor and functional status of the children. The battery of variables was suggested on the basis of a large study carried out by Kurelić et al. in 1975[8].

The morphological variables included body height (mm), body weight (dag), forearm circumference (mm) and triceps skinfold (1/10 mm). The measurements were taken according to the international biological program[21].

The motor variables included hand tapping (f), standing jump (cm), polygon backward (s), sit-ups (f), forward bow (cm), and bent arm hang (s).

The specific motor variables, which in this research have the criterion status, were selected to be the indicators of basic physical abilities of speed and strength, and to be representative to the assessment of situational-mo-

TABLE 1
YEARLY PLAN OF PHYSICAL EDUCATION EXPERIMENTAL PROGRAM

Contents	Months										Total
	IX	X	XI	XII	I	II	III	IV	V	VI	
Measurements	4									4	8
Athletics											
Walking and running	1	2	1	1	1	1	1	2	1		11
Jumps	1	2	1	1	1	1	1	1	1		10
Throws		2	1	1	1	1	1	1	1		9
Sports gymnastics											
Ground exercises	1	2	2	1	1	1	1	2	1		12
Apparatus exercises		1	2	1	1	1	1	1	1		9
Vaults		1	2	1	1	1	1	1			8
Games											
Sports games techniques		1	1	1	1	1	1	1	1		8
Elementary games	1	1	1			1		1		1	6
Relay games	1		1	1	1		1	1	1		7
Team games				1	1	1	2	1	2	1	9
Competitions											
Sports gymnastics						1			1		2
Dodgeball						1			1		2
Athletics							2			2	4
General preparatory exercises during each lesson											
Total	9	12	12	9	9	11	12	12	11	8	105

tor abilities for athletics, namely of sprint and throw. The following athletic variables were applied:

- M20V – 20 m run (the task is to pass a 20 m distance at a given signal at maximum speed, the results being recorded in tenths of second) matches sprint disciplines in athletics;
- MBLD – ball throwing (the task is to throw the 200 g ball from the above head, while standing, as far as possible, the results being recorded in decimetres) matches, as a preparatory exercise, mostly the athletic discipline of javelin throw.

The regression correlation analysis was selected to solve the given problem of the relation between the set of anthropometric and motor variables and certain situational-motor variable for athletics.

Results

The parameters of descriptive statistics show a positive quantitative shift of results of all the morphological and motor variables from the initial to the final measurement, in both control and experimental groups of subjects (table 2).

The results of analysis of variance, as demonstrated in table 2, exhibit statistically significant differences between the two groups of subjects in the initial measurement. These differences were recorded in two variables: hand tapping and bent arm hang, in favour of the control group of subjects.

By analysis of variance in the final measurement, s statistically significant difference between the two groups of subjects was recorded, i.e. predominantly in the motor variables of bent arm hang, sit-ups, forward bow, hand tapping, polygon backward, and in the criterion variables 20-m run and ball throwing. All these variables define a difference in favour of the experimental group. The differences in morphological measurements are less expressed and they refer to the greater muscle mass and less adipose tissue in the experimental group in relation to the control group (table 2).

Both groups of subjects achieved, between the two points of measurement, positive quantitative resultant shift, but this shift was more significant in the experimental than in the control group.

In the control group this was achieved in following variables: polygon backward, standing jump, sit-ups, ball throwing and 20-m run.

The experimental group, on the other hand, achieved statistically significant progress in the area of all observed variables, whereby it was clearly confirmed that specially programmed physical education lessons in the period of one academic year had yielded statistically signifi-

TABLE 2
DESCRIPTIVE STATISTICS (Mean±SD) AND ANALYSIS OF VARIANCE (p)

Variable	Total	Control	Exp	p
Initial measurement	Mean ±SD	Mean ± SD	Mean ± SD	
Stature (cm)	128.44 ± 5.46	128.37 ± 5.52	128.48 ± 5.22	
Body mass (kg)	27.03 ± 4.41	26.82 ± 4.49	27.19 ± 4.36	
Forearm circumference (cm)	17.85 ± 1.59	17.35 ± 1.45	18.23 ± 1.59	a
Triceps skinfold (mm)	11.47 ± 3.60	11.44 ± 3.50	11.49 ± 3.69	
Polygon backward# (s)	22.97 ± 6.24	23.25 ± 7.12	22.75 ± 5.48	
Forward bow (cm)	36.87 ± 8.50	36.38 ± 8.12	37.22 ± 8.78	
Hand tapping (taps/min)	19.18 ± 2.78	19.81 ± 3.00	18.70 ± 2.50	c
Standing jump (cm)	113.09 ± 17.39	111.50 ± 18.68	114.30 ± 16.29	
Sit-ups (per minute)	21.66 ± 6.37	21.96 ± 7.00	21.44 ± 5.84	
Bent arm hang (s)	10.91 ± 9.54	12.68 ± 11.72	9.57 ± 7.21	b
20-m run# (s)	4.94 ± 0.44	4.98 ± 0.44	4.91 ± 0.43	
Ball throwing (m)	10.57 ± 3.08	10.78 ± 3.23	10.40 ± 2.95	
Final measurement	Mean ± SD	Mean ± SD	Mean ± SD	
Stature (cm)	131.91 ± 5.49	131.37 ± 5.71	132.32 ± 5.30	
Body mass (kg)	29.81 ± 4.48	29.25 ± 4.56	30.24 ± 4.37	a
Forearm circumference (cm)	18.56 ± 1.56	18.08 ± 1.49	18.92 ± 1.51	a
Triceps skinfold (mm)	10.58 ± 3.46	10.73 ± 3.57	10.47 ± 3.37	a
Polygon backward# (s)	16.90 ± 4.02	17.47 ± 4.39	16.47 ± 3.67	a
Forward bow (cm)	40.21 ± 8.23	37.34 ± 7.00	42.39 ± 8.44	c
Hand tapping (taps/min)	21.31 ± 2.56	20.82 ± 2.33	21.68 ± 2.67	c
Standing jump (cm)	129.38 ± 17.11	127.63 ± 18.87	130.70 ± 15.57	a
Sit-ups (per minute)	26.88 ± 6.15	25.11 ± 6.58	28.22 ± 5.45	c
Bent arm hang (s)	18.81 ± 12.52	14.00 ± 9.98	22.45 ± 13.03	c
20-m run# (s)	4.58 ± 0.38	4.72 ± 0.38	4.48 ± 0.34	c
Ball throwing (m)	12.36 ± 3.35	11.97 ± 3.57	12.65 ± 3.16	a

#variable with opposite metric orientation, [a]$p<0.05$, [b]$p<0.01$, [c]$p<0.001$

cant quantitative changes both in the area of motor abilities and desirable morphological characteristics.

The relations between the morphological-motor variables as a predictor set of variables and the results in athletic variables of sprint and throw as a criterion, are demonstrated in table 3 and table 4 respectively.

Table 3 shows the results of regression analyses between the predictor set of variables and sprint as a criterion, separately for control, experimental and the overall subjects sample, both in initial and final measurement (6 regression analyses in total). Multiple correlation (ρ) in each regression analysis is statistically significant which proves that the applied set of morphological-motor variables represents a good results predictor in sprint, both in the subsample of pupils and in the overall primary school first graders sample. It can be noted that in the final measurement in relation to the initial the results prediction in sprint in the experimental group significantly increases, which is not the case in the control group of subjects. Namely, more basic motor abilities in sprint prediction contributed to the involving due to significantly more expressed transformational processes in the experimental group.

In the initial measurement the best results predictor in sprint (P-r and β) is variable for explosive strength assessment (standing long jump), whereas in the control group the movement frequency speed (hand tapping) and muscle mass (forearm circumference) had a greater influence on sprint results; the same was done in the experimental group by flexibility (forward bow). In the final measurement the number of predictors of criterion variable (sprint) has increased in all subject groups. In the control group the best results predictors in sprint are the motor abilities of explosive strength and trunk strength, while the morphological characteristics of muscle mass and body mass have positive and negative results respectively. In the experimental group the best results predictors were the following motor abilities: coordination, trunk strength, flexibility and explosive strength. It was exactly the more expressed quantitative changes in coor-

TABLE 3
REGRESSION ANALYSIS BETWEEN VARIABLES OF THE BIOMOTOR SPACE AND THE CRITERION VARIABLE (20-m run#)

Variable	Total				Control				Exp			
	r	P-r	β	p	r	P-r	β	p	r	P-r	β	p
Initial measurement												
Stature	–0.04	–0.05	–0.07		–0.05	–0.07	–0.10		–0.02	–0.09	–0.11	
Body mass	0.02	0.08	0.16		–0.03	0.11	0.28		0.08	0.08	0.14	
Forearm c.	–0.08	–0.14	–0.17	a	–0.11	–0.17	–0.31	a	0.01	–0.02	–0.02	
Triceps s.	0.09	–0.04	–0.05		0.10	–0.02	–0.03		0.10	–0.03	–0.03	
Polygon#	0.27	0.05	0.05		0.26	0.03	0.03		0.28	0.07	0.07	
Forward	–0.09	–0.03	–0.02		0.06	0.13	0.11		–0.18	–0.15	–0.14	a
Hand tap	–0.24	–0.10	–0.09		–0.36	–0.26	–0.23	c	–0.21	–0.10	–0.10	
Long jump	–0.49	–0.40	–0.43	c	–0.53	–0.43	–0.44	c	–0.42	–0.28	–0.30	c
Sit-ups	–0.24	–0.09	–0.09		–0.26	–0.11	–0.10		–0.24	–0.09	–0.09	
Bent arm	–0.16	–0.04	–0.03		–0.13	–0.00	–0.00		–0.22	–0.07	–0.06	
ρ			0.54	c			0.61	c			0.49	c
Final measurement												
Stature	–0.01	–0.10	–0.12		0.03	–0.09	–0.12		0.01	–0.12	–0.15	
Body mass	0.06	0.14	0.28	b	0.10	0.21	0.45	a	0.10	0.09	0.18	
Forearm c.	–0.12	–0.21	–0.27	c	–0.07	–0.25	–0.39	c	–0.01	–0.09	–0.11	
Triceps s.	0.21	0.04	0.05		0.19	0.01	0.01		0.23	0.05	0.06	
Polygon#	0.41	0.10	0.11		0.32	–0.00	–0.00		0.46	0.21	0.22	c
Forward	–0.24	–0.13	–0.11	a	–0.04	–0.01	–0.01		–0.25	–0.19	–0.17	b
Hand tap	–0.26	–0.08	–0.07		–0.27	–0.08	–0.08		–0.18	–0.08	–0.07	
Long jump	–0.45	–0.22	–0.23	c	–0.46	–0.29	–0.34	c	–0.44	–0.15	–0.16	a
Sit-ups	–0.41	–0.19	–0.18	c	–0.35	–0.15	–0.15	a	–0.36	–0.19	–0.18	b
Bent arm	–0.38	–0.13	–0.13	a	–0.30	–0.07	–0.07		–0.33	–0.10	–0.10	
ρ	Control		0.61	c			0.57	c			0.60	c

Total – (control + experimental group), Control – control group, Exp – experimental group, r – coefficient of correlation, P-r – coefficient of partial correlation, β – partial coefficients of regression, ρ – coefficient of multiple correlation, p – level of significance ($^{a}p<0.05$, $^{b}p<0.01$, $^{c}p<0.001$), #variable with opposite metric orientation

dination, flexibility and strength factors in the experimental group in relation to the control group that resulted in some different relations between the predictor set of variables and criteria. In other words, it brought about some changes in the morphological-motor structure. That structure determines the result in sprint in the experimental group in relation to the control group of pupils.

Based on the correlations of each single variable with the criterion, a latent structure, i.e. the complexity of sprint criterion in morphological-motor area, can be established. Thus, in the initial measurement a significant contribution to the latent sprint structure made by the following motor abilities: explosive strength, coordination, speed of movement frequency and repetitive trunk strength. In the final measurement the correlation of predictor variables and criteria increased, and so did their contribution to the latent sprint structure. This refers particularly to the development of coordination integration and of all the strength factors, as well as of movement speed and muscle tone regulation. These, combined, determine motor efficiency and sprint realisation.

Table 4 shows the results of the regression analyses between the predictor set of variables and throws as a criterion, separately for the control, experimental and the overall subjects sample, both in the initial and in the final measurement (6 regression analyses in total).

The growth and development aided by the kinesiologic transformation processes in physical education lessons influenced at the same time the development of basic motor abilities and the development of the specific athletic ability of throwing (ball throwing). It resulted in a greater biomotor prediction of the criterion variable of ball throwing in the final measurement in relation to the initial measurement. Generally, i.e. for the overall subjects sample the best predictor of criterion variable – ball throwing – are explosive strength and trunk strength. In the experimental group of pupils it is followed by the coordination development as well as the development of the total body mass.

From the initial to the final measurement the latent structure of criterion variable – ball throwing changed, so the contribution of coordination increased as well as

TABLE 4
REGRESSION ANALYSIS BETWEEN VARIABLES OF THE BIOMOTOR SPACE AND THE CRITERION VARIABLE (Ball throwing)

Variable	Total				Control				Exp			
	r	P-r	β	p	r	P-r	β	p	r	P-r	β	p
Initial measurement												
Stature	0.19	0.09	0.13		0.07	0.03	0.04		0.30	0.20	0.25	[b]
Body mass	0.14	0.07	0.14		0.04	–0.01	–0.03		0.21	0.12	0.21	
Forearm c.	0.06	–0.05	–0.07		0.05	–0.01	–0.02		0.09	–0.07	–0.09	
Triceps s.	–0.03	0.00	0.01		–0.06	0.11	0.16		–0.01	–0.09	–0.11	
Polygon[#]	–0.27	–0.10	–0.10		–0.25	–0.08	–0.08		–0.32	–0.18	–0.19	[a]
Forward	0.02	–0.04	–0.03		0.02	–0.04	–0.03		0.02	–0.02	–0.02	
Hand tap	0.18	0.04	0.04		0.20	0.05	0.05		0.17	0.11	0.10	
Long jump	0.39	0.28	0.29	[c]	0.48	0.38	0.41	[c]	0.31	0.17	0.17	[a]
Sit–ups	0.31	0.19	0.19	[c]	0.35	0.23	0.22	[b]	0.28	0.13	0.13	
Bent arm	0.16	0.07	0.06		0.17	0.08	0.07		0.11	0.01	0.01	
ρ			0.50	[c]			0.55	[c]			0.52	[c]
Final measurement												
Stature	0.17	0.08	0.11		0.12	0.14	0.18		0.21	0.05	0.06	
Body mass	0.15	0.06	0.13		0.07	–0.08	–0.17		0.19	0.21	0.43	[c]
Forearm c.	0.11	–0.03	–0.04		0.14	0.07	0.10		0.05	–0.12	–0.15	
Triceps s.	–0.03	0.06	0.07		–0.02	0.16	0.20	[a]	–0.02	–0.08	–0.10	
Polygon[#]	–0.37	–0.13	–0.13	[a]	–0.37	–0.12	–0.12		–0.36	–0.15	–0.15	[a]
Forward	0.07	–0.06	–0.05		0.00	–0.11	–0.09		0.07	–0.00	–0.00	
Hand tap	0.23	0.05	0.04		0.21	–0.02	–0.02		0.23	0.09	0.08	
Long jump	0.47	0.29	0.32	[c]	0.46	0.28	0.32	[c]	0.47	0.29	0.32	[c]
Sit-ups	0.35	0.15	0.14	[b]	0.37	0.21	0.21	[b]	0.30	0.06	0.05	
Bent arm	0.29	0.14	0.14	[b]	0.36	0.21	0.20	[a]	0.23	0.12	0.11	
ρ			0.57	[c]			0.59	[c]			0.59	[c]

Total – (control + experimental group), Control – control group, Exp – experimental group, r – coefficient of correlation, P-r – coefficient of partial correlation, β – partial coefficients of regression, ρ – coefficient of multiple correlation, p – level of significance ([a]$p<0.05$, [b]$p<0.01$, [c]$p<0.001$), [#]variable with opposite metric orientation

all the strength factors and the movement frequency speed in the criterion latent structure. As far as the strength factor is concerned, leg strength, followed by trunk strength and arms strength, have the greatest contribution in the latent structure of throw, so in the exact order in which muscle groups are activated in the realization of throwing in athletics (for example javelin throw).

Discussion

The results showed an interactional connection between the morphological and motor status with success in the athletic disciplines of sprint and throw in 6 to 8 year old boys. Those relations are generally similar to those found in top-quality athletes, sprinters and throwers. A maximum of energy – strength needs to be generated in these disciplines in the short time period: in sprint it refers to the maximum relative strength related to the above average active muscle mass, and in throwing it refers to maximum absolute strength, determined by the total body mass. In some development phases a certain state of morphological motor status is also achieved, limiting the success in sprint and throw. This is done by activating such morphological motor characteristics, which an individual potentially disposes of to a higher extent. The success in sprint and throw is thus limited either by the lack of minimum of certain characteristics and abilities and/or by the greatness of variability in those characteristics and abilities that determine to the highest extent the result in those athletic disciplines. So, in relation to certain stages of morphological motor status in which groups of subjects can be found, certain relations which determine the success in sprint and throw are also established. Also the experimental program of kinesiologic education in primary school first graders has had an impact on the forming of an anthropological set, which is optimal for the realisation of two athletic disciplines (sprint and throw) at that age.

Biomotor development in 6 to 8 year old boys, mostly generated by the athletics treatment, is in accordance wi-

th the biomechanical characteristics of sprint and javelin throw. Therefore it is possible to determine the development phases both in the morphological motor status and in the development of specific motor knowledge and abilities for athletics. Both these phases are in a parallel progress and athletic school for 6 to 8 year old boys mostly takes place in two phases. The first phase refers to the first and the second grade, and the second phase refers to the third and the fourth primary school grade. The phase of primary selection follows afterwards. These are for sprint before puberty, between 11 and 12 years of age, i.e. in the fifth and in the sixth grade of primary school, and for throws and javelin throw after puberty between 11 and 15 years of age, i.e. in the first grade of high school.

The 20m run is by its structure a cyclic movement and it only appears a simple motor activity. A synchronized innervation and some control of synergist and antagonist tone are not sufficient for maximum fast movement performance. Thus, for example, determining of the optimal relations of pace length and frequency, as well as other parameters, is of extreme importance. All this points to the fact that this is a complex motor movement and that the speed of movement performance, typical for the 20m run, also highly depends on higher regulation mechanisms, responsible for the structuring of movement.

Fig. 1. Diggory Brooke, New Zealand champion and Commonwealth games representative.

The dominant involvement of explosive strength in a successful 20m run is conditioned by the biomechanic and structural characteristics of repetitive movement cycles of this motor activity.

An active takeoff of the reflex leg and a fast withdrawal of the swinging leg, bent in the knee joint forwards and upwards, are the most important parts of this sprint distance, providing a high level of running speed. In this activity, mostly engaged in the reflection action are muscle groups of lower extremities, thigh and lower leg extensors and plantar flexor feet. All of them also participate in the success of motor tests realisation, intended for explosive strength assessment.

It is well known that in javelin throw the total length of javelin flight depends on the initial throw speed, the angle of the throw, air resistance and the height of the throw. The most important factor which determines the result in throw is definitely the initial speed of javelin throw. In the final part of throwing, the thrower tries to increase the adding of strength on the javelin as well as to perform this movement in the shortest time possible. Reduction of influence time on javelin depends on the strength and speed of nerve impulses. Muscles, from the bigger and stronger ones to those smaller which shorten faster, connectively engage in the activity.

Although ball throwing from the standing position matches in its structure only the phase of »final effort« in javelin throw, other techniques phases are also briefly described in order to recognize the complexity of this specific motor knowledge as well as to determine the proces-

Fig. 2. Eight-year-old girl in ball throwing position.

ses of learning and acquisition of that motor structure within the athletic sport school.

So in the »final effort« phase it is necessary for the thrower to move with the left shoulder forwards as well as with the left foot forwards (presuming he uses the right hand to throw). To increase muscle mass of the shoulder girdle (mostly loaded at throwing) it is important to rotate the bent leg towards the inside as well as to make the wrist supination with the knee, before positioning the left leg.

The most active part of the »final effort« actually starts with positioning the left leg on the ground from heel to the whole foot. The thrower continues to »position« himself under the apparatus. It is enabled by the run-up inertia, which is done by the slowing activity of the tense left part of the body from leg and shoulder, as well as by the active performance – moving towards extending and rotating. At that time, the thrower, connectively performs the elements of the final effort: hip movement, chest turn forwards (which causes the arm with the javelin to be positioned behind the back), and finally the throw.

All parts (elements) of the final effort represent a single movement. Omitting one of the elements of the movement leads to the reduction of the performance path on the apparatus and increases the throw time.

In the throwing process, the speed at which the javelin moves gradually increases. The movement speed of hip joint and shoulder and elbow joint initially increases and then decreases rapidly. Such rapid speed decrease occurs at the same time as the acceleration becomes negative, i.e. they are directed opposite of the movement direction.

The maximum of the negative acceleration is achieved first in the hip joint and afterwards in the elbow. This sudden acceleration decrease in the shoulder joint and elbow matches the moment of the highest javelin speed increase.

By comparison of these and the earlier obtained results, which can be found in the references[22–26], we come to the conclusion how existing approaches in the education of athletic disciplines of sprint and throw with primary school children need to be revised. The children education model in athletics, proposed in this study, is defined by the following elements: development of the basic motor abilities, especially of the psychomotor speed, explosive strength, aerobic endurance and coordination (along with the adequate load, defined by the intensity parameters and work volume) and motor learning of specific motor knowledge, i.e. technique of athletic disciplines.

The aim in this period (6–7 years), is to learn the basic movement structures and to develop motor skills. Skills development needs to be well structured, i.e. designed and properly supervised.

The first possible influence, i.e. room for the accelerated speed adaptation occurs at the age 6–8 in girls and 7–9 in boys. Excluding the development of specific skills in this phase will surely have negative consequences on the future participation in athletics and physical activity in general. It also needs to be mentioned that in activity planning and programming it is not about periodisation but the whole program is adequately structured and properly supervised.

It includes practising and mastering basic movement structures before the development of specific skills per sport and disciplines is introduced.

It is also important to emphasize the overall development of physical capacity of the young future athletes. Therefore coordination, agility, balance and speed need to be developed. Proper running, jumping and throwing technique needs to be learned by using the »athletic alphabet« exercises. For running it includes high and low skip, walking on the front and the back part of feet, lower leg swinging by one-leg and two-leg hops, exercises on the »ladder« on the ground, starting from different positions, overrunning short, up to 20m distances. For javelin, the exercises to be performed are ball throwing from different positions: from kneeling position, sitting position, standing position (turned towards the throwing direction) and from the side position. Then throwing by aiming at different moving objects as well as at fixed targets – objects, later with a certain elevation, distance and finally from the shorter and longer run-ups.

It is also important to introduce and apply flexibility exercises, to develop speed, strength and especially endurance by using different games. It is necessary to develop rectilinear, side and multidirectional speed with duration of repetition less than 5 seconds, as well as to introduce strength training by using exercises with one's own body mass, as well as medicine and Swiss ball exercises.

Acknowledgement

This study was supported by the grant No. 177-0000000-3410 from the Croatian Ministry of Science, Education and Sport.

REFERENCES

1. KATIĆ R, ZAGORAC N, ŽIVIČNJAK M, HRASKI Ž, Coll Antropol, 18 (1994) 141. — 2. KATIĆ R, VISKIĆ-ŠTALEC N, Croat Sports Med J, 11 (1996) 16. — 3. KATIĆ R, Coll Antropol, 27 (2003) 351. — 4. BABIN J, KATIĆ R, ROPAC D, BONACIN D, Coll Antropol 25 (2001) 153. — 5. KATIĆ R, MALEŠ B, MILETIĆ D, Coll Antropol, 26 (2002) 533. — 6. TRAVIN JG, SUSLOV FP, Laka Atletika. (Fizkultura i sport, Moskva, 1989). — 7. ŠNAJDER V, Differences in various stages of short distance running between children of 12 and top sprinters. (Moving Towards Excellence, AIESEP World Convention, Loughborough, Loughborough Univesity, 1990). — 8. KURELIĆ N, MOMIROVIĆ K, STOJANOVIĆ M, ŠTURM J, RADOJEVIĆ Đ, VISKIĆ-ŠTALEC N, Struktura i razvoj morfoloških i motoričkih dimenzija omladine. (Institut za naučna istraživanja Fakulteta za fizičko vaspitanje, Beograd, 1975). — 9. MRAKOVIĆ M, FINDAK V, GAGRO I, JURAS V, RELJIĆ J, Delegatski bilten, Zagreb 82

(1986). — 10. KATIĆ R, PEJČIĆ A, VISKIĆ-ŠTALEC N, Coll Antropol, 28 (2004) 261. — 11. KATIĆ R, PEJČIĆ A, BABIN J, Coll Antropol, 28 Suppl 2 (2004) 357. — 12. KATIĆ R, SRHOJ LJ, PAŽANIN R, Coll Antropol, 29 (2005) 711. — 13. LASAN M, PAŽANIN R, PEJČIĆ A, KATIĆ R, Kinesiologia Slovenica, 11 (2005) 25. — 14. CARTER JEL, HEATH BH, Somatotyping development and applications (Cambridge University Press, Cambridge, UK, 1990). — 15. GUALDI-RUSSO E, GRAZIANI I, J Sports Med Phys Fitness, 33 (1993) 282. — 16. HEATH BH, Applying the Heath-Carter somatotype method. In: EIBEN OG (Ed) Growth and Development: Physique (Academiai Kiado, Budapest, 1977). — 17. ŠTEPNIČKA J, Somatotypes of Czechoslovak Athletes. EIBEN OG (Ed) Growth and Development: Physique (Academiai Kiado, Budapest, 1977). — 18. BALL TE, MASSEY BH, MISNER JE, MCKEOWN BC, LOHMAN TG, J Sports Med Phys Fitness, 32 (1992) 364. — 19. KATIĆ R, Biol Sport, 13 (1996) 47. — 20. ŠNAJDER V, Kineziologija, 12 (1982) 43. — 21. WEINER JS, LOURIE JA, Practical human biology (Academic Press, London, 1981). — 22. BABIN J, ZAGORAC N, Physical culture Beograd, 40 (1986) 9. — 23. ZAGORAC N, KATIĆ R, SRHOJ V, SRHOJ LJ, . (IV. congress of sports pedagogues of Yugoslavia and I. international symposium Sport of the young, Ljubljana-Bled, 1990). — 24. ZAGORAC N, Kineziologija, 22 (1990) 63. — 25. GOZZOLI C, LOCATELI E, MASSIN D, WANGERMAN B, IAAF – Kids Athletics – A Practial Guide, Second edition (IAAF, Monaco 2002). — 26. NEWMAN S, Runn, Jump, Throw – Youth Development Programe (Athletics, New Zealand 2007).

R. Katić

Faculty of Natural Sciences, Mathematics and Kinesiology, University of Split, Teslina 11, 21000 Split, Croatia
e-mail: katic@pmfst.hr

RAZVOJ BIOMOTORIČKIH OBILJEŽJA I ATLETSKIH SPOSOBNOSTI SPRINTA I BACANJA DJEČAKA STAROSNE DOBI OD 6 DO 8 GODINA

S A Ž E T A K

Istraživanje je provedeno s ciljem ispitivanja utjecaja posebno programirane nastave tjelesne i zdravstvene kulture na biomotoričke promjene dječaka, kao i utjecaj tih promjena na relacije između skupa morfoloških i motoričkih varijabli s atletskim varijablama za procjenu sposobnosti sprinta i bacanja. U tu svrhu ukupni uzorak od 325 učenika prvih razreda osnovnih škola na području grada Splita u dobi od 6 do 8 godina podijeljen je na kontrolnu skupinu ispitanika (N=140) koja je pohađala redovitu nastavu tjelesne i zdravstvene kulture i na eksperimentalnu skupinu (N=185) koja je pohađala posebno programiranu nastavu baziranu na elementima atletike, sportske gimnastike, igara te opće pripremnih vježbi. Relacije između prediktorskog skupa varijabli sastavljenog od 4 morfološke mjere i 6 motoričkih testova s kriterijima sprinta i bacanja loptice utvrđene su regresijskom korelacijskom analizom i to na početku i na kraju školske godine. Obje skupine ispitanika postigle su između dviju točaka mjerenja pozitivan kvantitativni rezultatski pomak s tim da je taj pomak znakovitiji kod eksperimentalne skupine u odnosu na kontrolnu i to posebno u motoričkim sposobnostima koordinacije, fleksibilnosti, frekvencije pokreta te eksplozivne, repetitivne i statičke snage. U finalnom mjerenju u odnosu na inicijalno mjerenje povećao se broj značajnih prediktora za kriterijske varijable sprinta i bacanja loptice kod obiju skupina ispitanika. Kod kontrolne skupine najbolji prediktori rezultata u sprintu su od motoričkih sposobnosti eksplozivna snaga i snaga trupa, a kod eksperimentalne skupine najbolji prediktori rezultata u sprintu su motoričke sposobnosti: koordinacija, snaga trupa, fleksibilnost i eksplozivna snaga. Od morfoloških obilježja mišićna masa ima pozitivni utjecaj a tjelesna težina negativan utjecaj na rezultat u sprintu. Najbolji prediktor rezultata u bacanju loptice je eksplozivna snaga i snaga trupa što kod eksperimentalne skupine učenika još dodatno prati razvoj koordinacije kao i razvoj ukupne tjelesne mase. Komparacijom ovih i ranije dobivenih rezultata predložen je novi model rada za discipline sprinta i bacanja u okviru atletske sportske škole.